



Development and Application of Sequences As An Analytical Tool for Aviation Incidents

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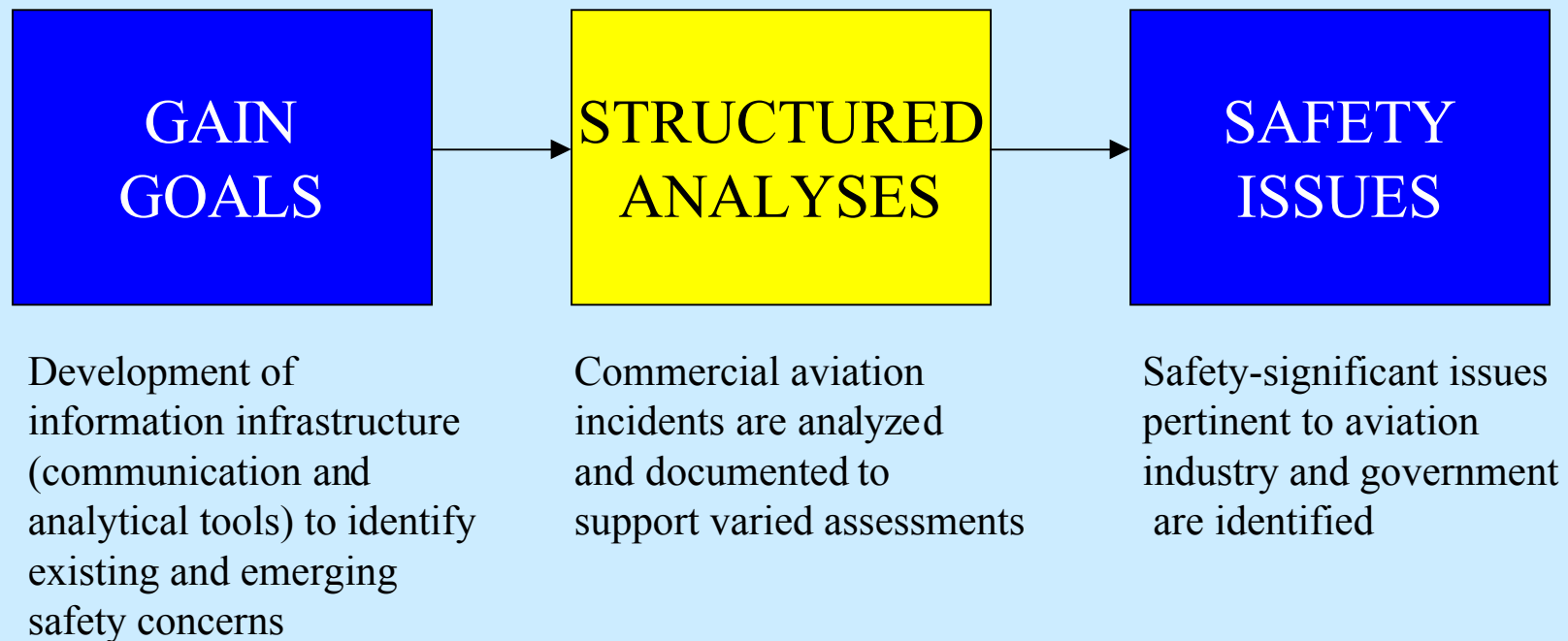


Background for Presentation

- **Oak Ridge National Laboratory (ORNL)—Who we are**
 - 1 of 7 multidisciplinary Department of Energy labs
 - Located in Oak Ridge, Tennessee
 - Managing contractor: Lockheed Martin Energy Research
 - Mission areas
 - Basic science, engineering, and technology
 - Advancing and applying technology to support other federal agencies and U.S. industry
- **Analysis methods and information systems discussed are representative to support ORNL has provided for over 15 years to**
 - U.S. Nuclear Regulatory Commission
 - U.S. Department of Energy



Structured Analyses—Key Link for Addressing GAIN Safety Goals





Key Elements in Identifying Safety-Significant Issues

•Structured Analyses of Incidents—Objectives

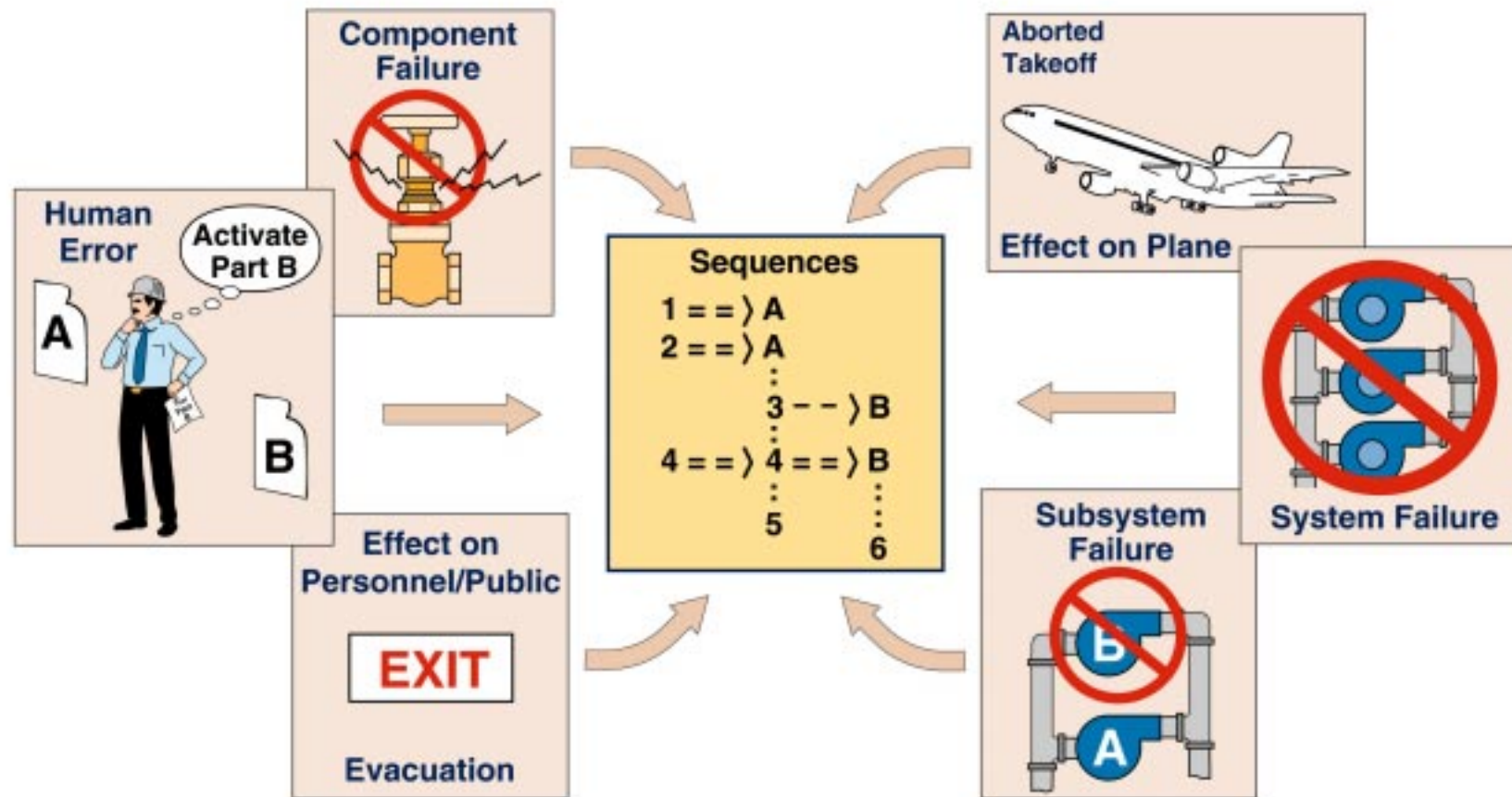
- Represent “evaluated, engineering-based information”
- Consistent structuring/encoding of incidents
- Provide information to conduct varied analyses
- Make information available to all parties to leverage collective efforts

•Structured Analyses of Incidents—Implementation

- Reduce narrative text to encoded, searchable sequences
- Accommodate both component/system failures and personnel errors
- Establish a set of encoding conventions for consistency
- Access by cross section of users via intuitive interface



Six Building Blocks Are Used to Structure Incident Assessments





Development of Sequences—Incident Matrix

- Rows of matrix—provide details on individual equipment failure or personnel error
- Columns of matrix—develop sequential relationship for rows as to how individual rows or steps are linked ➡ what happened before or after a step of interest



Example Accident Description

(Data Source: NTSB Aviation Accident/Incident Database)

Narrative:

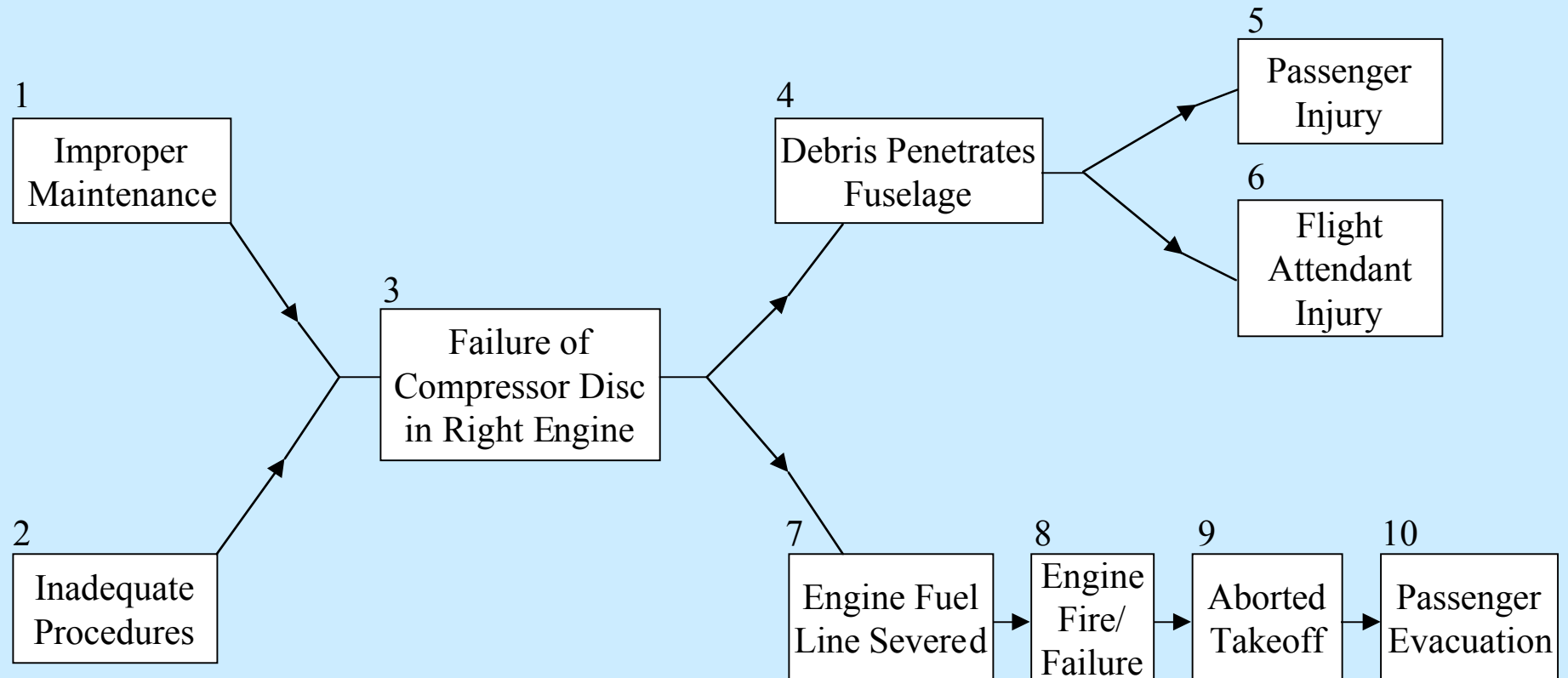
As flight zzz began its **takeoff** roll, a “loud bang” was heard by occupants, the right engine fire warning light illuminated, the crew of a following airplane reported that the **right engine was on fire**, and the **takeoff was rejected**. **Shrapnel** from right engine **penetrated the fuselage** and right engine main **fuel line**, and a cabin fire erupted. The airplane was stopped on the runway, and the captain ordered **evacuation** of the airplane. A **flight attendant** received serious puncture wounds and thermal injuries; another **F/A and 5 passengers** received minor **injuries**. Investigation revealed that an uncontained failure of the right engine had occurred due to **fatigue failure of its 7th stage high compressor disc**. Analysis indicated that the **fatigue crack had originated before the disc was last overhauled at a contractor repair station but was not detected**. Also, evidence revealed **lack of adequate recordkeeping** and failure to use process sheets to document overhaul/inspection procedures.

Probable Cause:

Failure to perform proper inspection of 7th stage high compressor disc, thus allowing detectable crack to grow to a length at which the **disc ruptured** propelling engine fragments into fuselage and **severing right engine main fuel line**.



Graphical Representation of Sequences for Example





Sequence Coding of Example

Aircraft Make/Model: ZZZZZ

Phase of Flight: Takeoff

Event Type: Accident

Operator Name: XXXXX

Aircraft Damage: Substantial

Airport Name: YYYYYY

Injury Severity: Serious

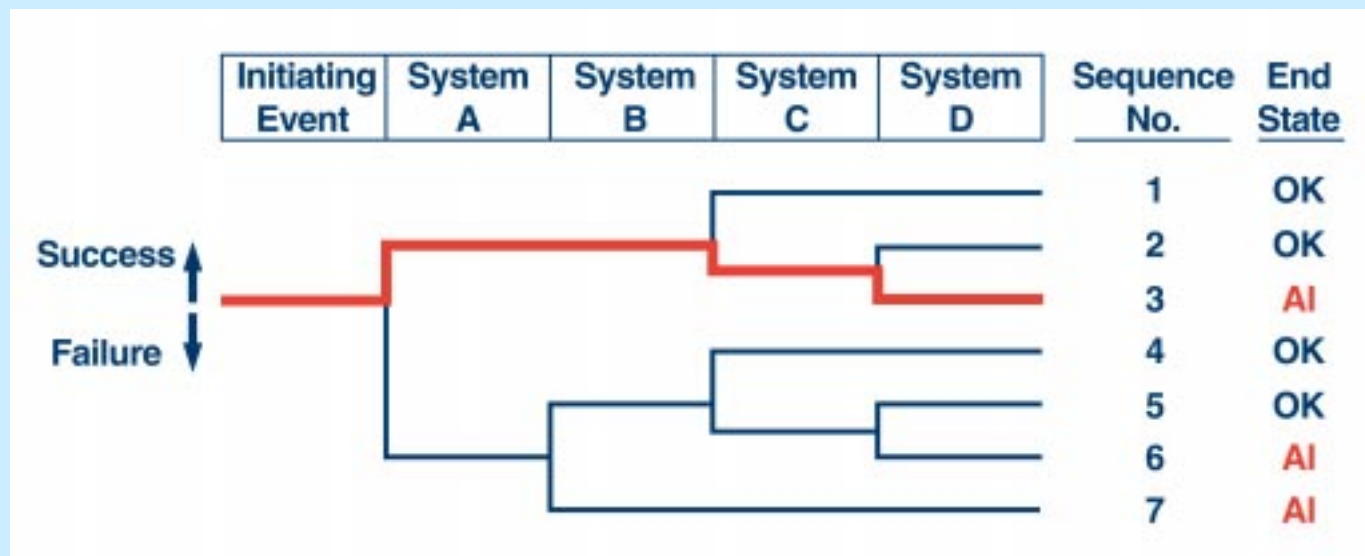
Date of Incident: DDMMYY

XX = effect on plane; YY = effect on personnel/public



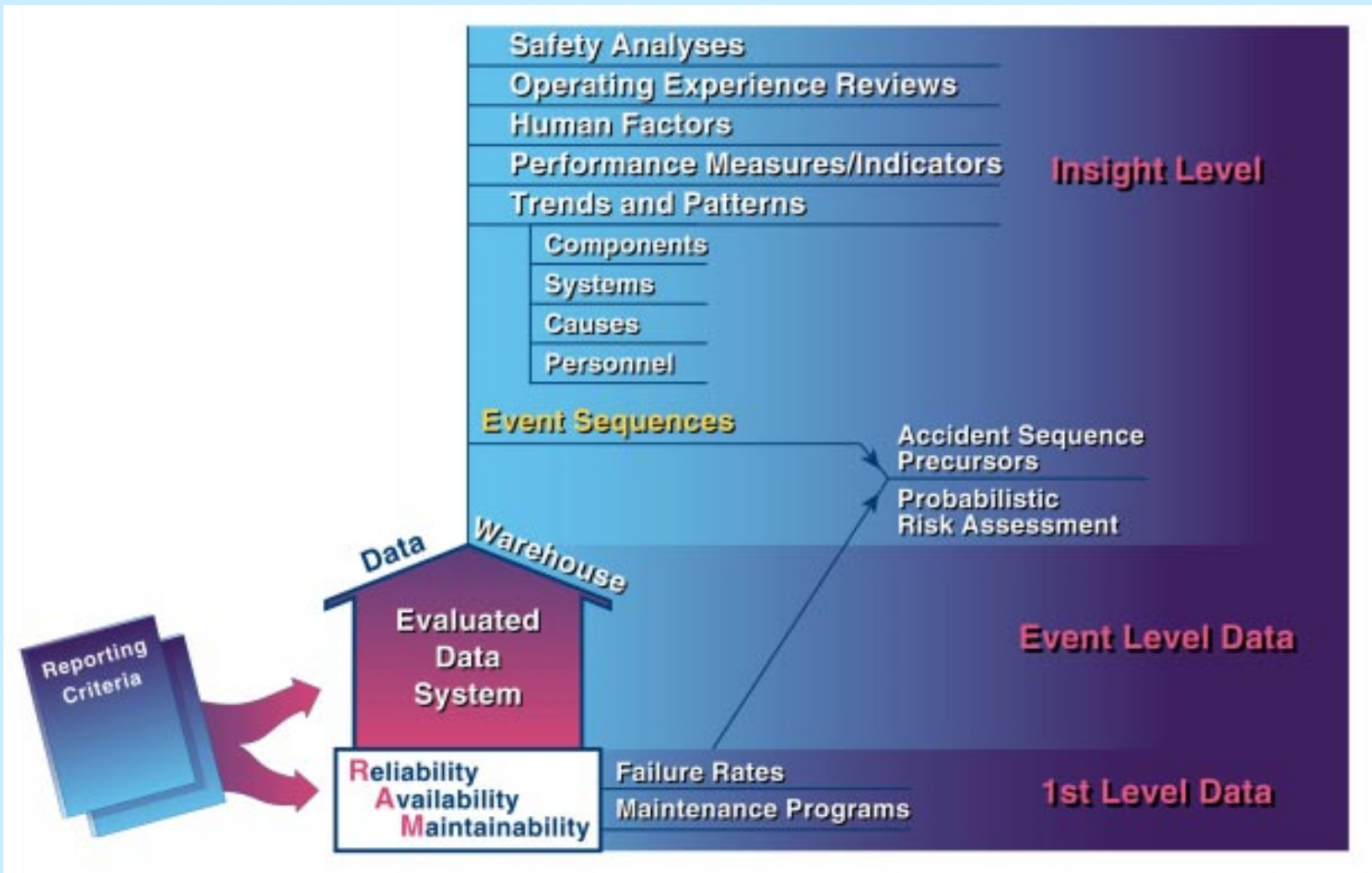
What Is An Accident Sequence Precursor?

- **Incident involving important elements of accident sequences of interest**
 - An initiating event, coupled with one or more postulated failures, that could have resulted in the accident of interest (AI)
 - Observed failures, coupled with one or more postulated failures or events, that could have resulted in AI
- **Accident sequence precursor analysis amenable for various phases of flight**





Integrated Safety Management System





Application of Sequences in Improving Aviation Safety

Aviation Week & Space Technology, July 13, 1998:

Captain K. Scott Griffith, managing director of flight operations safety—American Airlines

David Marx, aviation safety consultant

“Incident data, rather than accident data, must be the cornerstone of the safety process. Accident rate reduction will be the ultimate outcome, Such events can be the precursors to major accidents.”

“We must look beyond accidents to the underlying precursors made visible through the investigation of our everyday mishaps and errors.”



Constructing sequences of incidents supports identification of accident precursors